	Project Acronym: S3UNICA ***Project Title:*** Smart SpecialiSation UNIvercity Campus ***Program:*** **Interreg Europe** **Topic**: Low carbon economy **Specific Objective:** 3.1. Improving low-carbon economy policies ***Subsidy contract no.:*** PGI06201 ***Starting date:*** 1st August 2019 ***Ending date:*** 31st July 2023

CAMPUS TECHNICAL SOLUTION PUBLICATION

LUT University

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1. Introduction[1]

1.1. LUT University

LUT University (Lappeenranta-Lahti University of Technology LUT) is a **pioneering science university in Finland**, bringing together the fields of science and business since 1969. The LUT University international community (Fig. 1) is composed of approximately **6,500 students and experts engaged in scientific research and academic education**.

Fig.1 LUT University lies on the shore of lake Saimaa

At the beginning of 2015, the university shifted to an organisation model which does not have traditional faculties and departments. Instead, the university consists of **three distinct schools which focus** on the following research topics:

- **LUT School of Energy Systems**: Energy Technology; Electrical Engineering; Sustainability Science; Mechanical Engineering.

[1] www.lut.fi

- **LUT School of Engineering Science**: Chemical Engineering; Computational Engineering and Physics; Industrial Engineering and Management; Software Engineering and Digital Transformation.
- **LUT School of Business and Management**: Strategy, Management and Accounting; International Business, Marketing and Entrepreneurship.

LUT University will start degree programmes in social and behavioural sciences and communication and information sciences in autumn 2023.

The current **LUT strategy 2020-2030** is thus presented

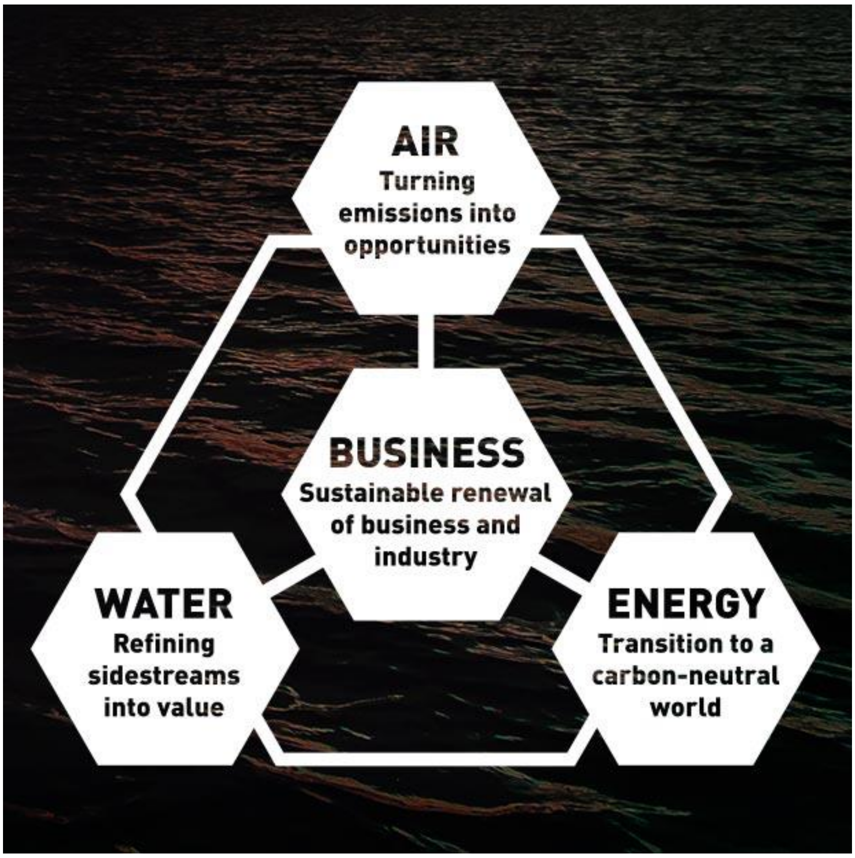

Fig.2 LUT University's current strategy

1.2. International comparisons and university rankings

LUT is one of the world's 20 most promising and rapidly developing challenger universities, according to a report by the **Firetail consulting firm**[2], who listed 20 universities around the world that could **challenge the academic elite and become globally renowned by the year 2030**. What these "rising stars" have in common is their:

- **balance of long-term vision with short-term execution of strategy**.
- **Clear view of the changing world and their role in it**.
- **Robust plan to generate the resources, people and culture needed to be successful.**
- **Focus on impact**.

1.2.1. Times Higher Education (THE) Impact Ranking

Times Higher Education (**THE**) **World University Rankings**[3] is one of the world's most highly regarded university ranking systems. It lists the **top 1300 universities in the world**. The areas assessed are **research**, **teaching**, **international outlook**, and **funding** and the ranking is based on 13 indicators.

LUT was ranked among the top 201–300 out of 1115 universities in the 2021 "THE Impact Rankings", thanks to its promotion of **Responsible Consumption and Production**. LUT obtained top scores in **water and clean energy research, spinoff companies, sustainable development education and sustainability reporting**.

Moreover, **LUT School of Business and Management** (LBM) is among the **world's top 200 business schools in the latest** "THE" World University Rankings 2020 for business and economics subjects. LBM's ranking is **176-200 among a total of 632 business schools listed in the ranking**.

[2] https://www.firetail.co.uk/class-of-2030/

[3] https://www.timeshighereducation.com/world-university-rankings.

1.2.2. Academic Ranking of World Universities (ARWU) Shanghai Ranking

The world's first global university ranking, published since 2003, is the **Academic Ranking of World Universities (ARWU)**[4] – also known as the **Shanghai Ranking**. LUT earned its first ranking position on the **Shanghai list in 2018 among the top 801-900 universities. Many of LUT's research fields were also ranked on the Shanghai list of academic subjects**.

The Shanghai list scores universities based on **citations to studies and researchers** and, for example, the **number of Nobel Prize and Fields Medal winners**. The assessment emphasises publications in natural sciences and medicine. In the most recent Shanghai Ranking in 2020, **LUT was ranked 901-1000**.

1.2.3. QS World University Rankings

LUT took part in the **QS World University Rankings (QS)** for the first time in **2016**. Along with "THE" and the "Shanghai list" (Academic Ranking of World Universities, ARWU), **QS is one of the leading university rankings in the world**. It ranks universities based on **six indicators** and in different areas, including **academic reputation**, **employer reputation**, **international faculty**, **citations per faculty member, the student-to-faculty ratio,** and **the number of international students**.

In the most recent QS rankings published in June 2021[5], LUT's position was 414th among a total of 1300 universities listed due to its **research intensity**.

[4] https://www.shanghairanking.com/rankings/arwu/2020
[5] https://www.topuniversities.com/university-rankings/world-university-rankings/2022

2. Campus activities towards energy efficiency and carbon neutrality

2.1. LUT Campus Energy Management

The **University Properties of Finland Ltd (SYK)** is the owner of LUT University campus buildings in Lappeenranta. **SYK is a nationwide owner and developer of higher education campuses outside of the Helsinki metropolitan area**. It is owned by nine universities outside the Helsinki metropolitan area and the Finnish State.[6]

As the property owner, **SYK is responsible of the investments at the campus** and it also manages the **continuous improvement of energy and water use efficiency** is managed by SYK. Moreover, it **develops energy efficiency** in close cooperation with the universities and energy consultants (Fig. 3):

- Energy management of campuses involves both local and centralised specialist services, e.g. HVAC specialists.
- Local technical manager coordinates the management.

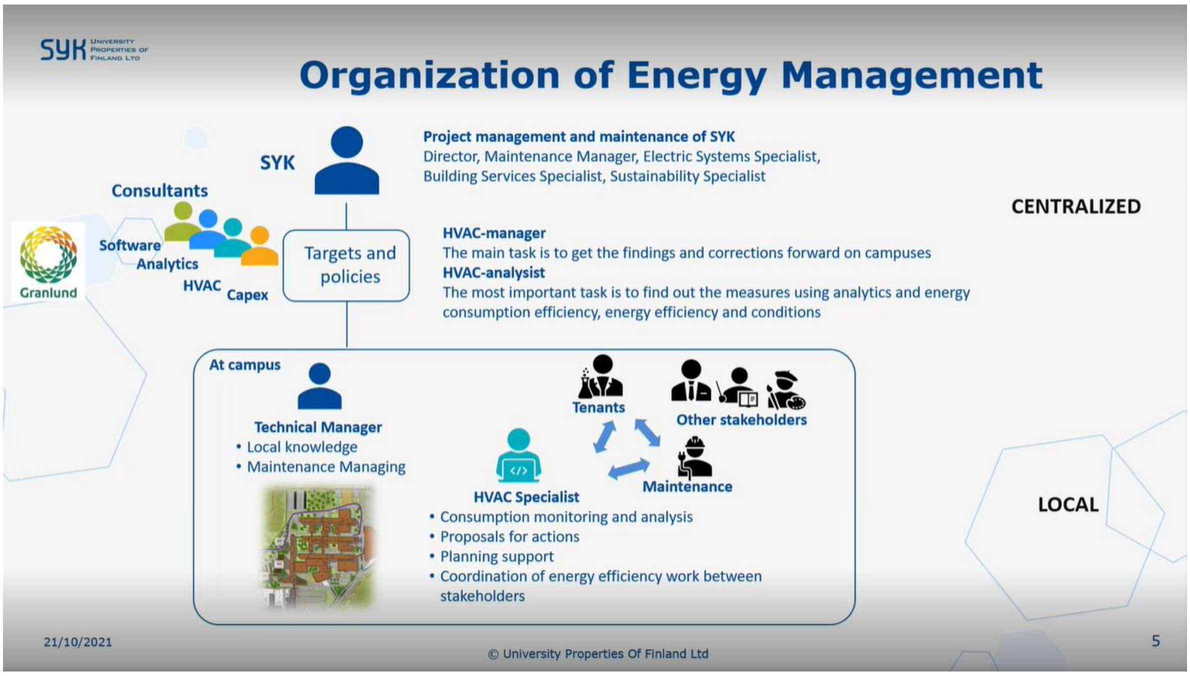

Fig. 3. Energy management in SYK owned campuses.
Ari-Pekka Lassila's CTM presentation Oct 21, 2021

[6] www.sykoy.fi

Energy (heat and electricity) and water consumption are monitored on hourly basis, and they are reported in monthly reports. Consumption data is compared to the history data, in order to monitor the effects of taken efficiency measures. The development trend of some key figures on all SYK operated campuses is presented in the following table[7].

	2020	2019	2018	2017	2016	Unit
Emission						
CO_2	35 529	39763	40993	55 001	57 050	tons of CO_2
CO_2	27,9	31,9	32,0	43,1	45,9	kg CO_2/brm^2
Consumption of purchased energy						
Heating, measured	156 308	182 321	173 146	170 217	169 353	MWh
Heating, weather-adjusted	147,8	154,9	144,7	147,9	141,2	kWh/brm^2
Electricity	127 628	140 970	138 520	131 089	129 835	MWh
Electricity	102,1	116,6	109,2	106,3	102,9	kWh/brm^2
Produced energy						
Solar power produced at our campuses	417	415	235,5	238	210	MWh
Water consumption						
Total amount	228 020	331 849	330 935	332 585	348 541	m^3
Relative to floor area	190,3	263,9	273,4	263,4	276,1	litres/brm^2

[7] Ecological sustainability of operations in SYK campuses 2016–2020 (https://vuosikertomus.sykoy.fi/2020/en/responsibility/ecological-sustainability/)

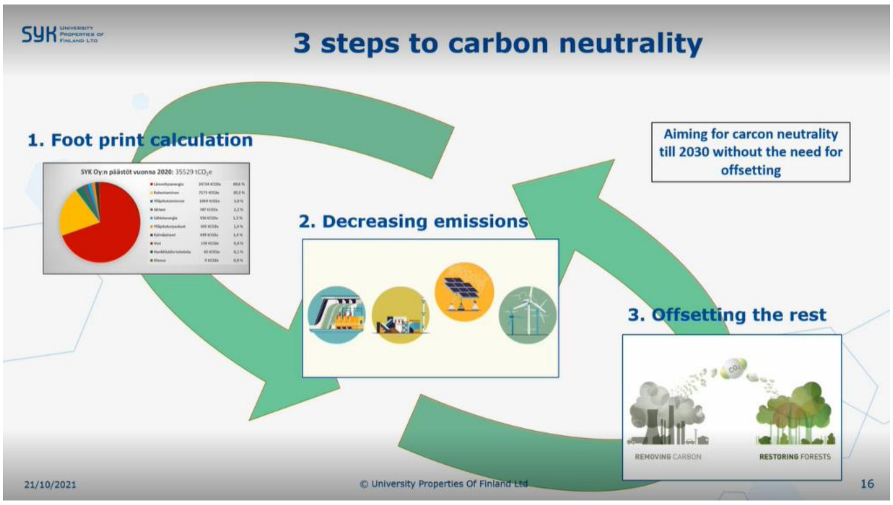

Fig. 4: SYK targets for carbon neutrality.
Source: Ari-Pekka Lassila's CTM presentation Oct 21, 2021)

sYK has established its **own targets for improving energy efficiency and decreasing carbon footprint at each university campus it owns**. SYK calculates the carbon footprint and sets the goals for emission decrease for its operations. The target for SYK is to be carbon negative without any outside offsetting by the year 2030 (Fig. 4). These targets reflect to the development plans of each university campus.

LUT supports SYK in energy efficiency and carbon neutrality by **conducting research on energy solutions and developing innovative methods and solutions for better system performance**. LUT has established for its own activities the goal to be carbon negative by 2024.

LUT Green Campus is an environment where the **daily building system operations connect with energy related research** (Fig. 5). On the other hand, the campus buildings are being operated as normal public buildings, by **standard high performance heating, ventilation and air conditioning systems**. Innovative building related energy applications can be tested as parts of Green Campus. Applications can be connected to standard building systems, when applicable.

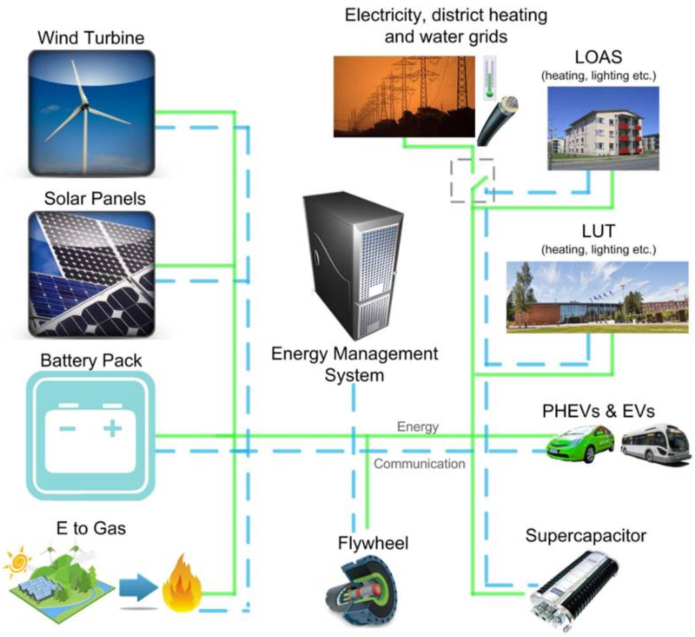

Fig. 5: The LUT Energy Management System

The “**LUT Green Campus”** is an umbrella project of LUT that covers for instance the laboratory environment utilized to demonstrate a variety of microgrid functionalities in the power grids and the communication networks. The LUT Green Campus grid consists of a **132 kWh battery energy storage connected to an low-voltage direct current (LVDC) test network, 206 kWp of solar photo-voltaic (PV), 20 kW of wind power, a smart electric vehicle (EV) charging pole and several external data streams to enable novel control schemes.** The present laboratory setup provides highly flexible ICT resources to implement proposed communication interfaces and control schemes. The present system with battery resource enables functionalities such as local voltage regulation, reactive power compensation, frequency containment reserve, production and consumption peak shaving[8].

The targets and task of the LUT Energy Management System are:

- **Processing of measurement data and background information**.
- **Cost efficient and optimized operation of active resources** (distributed generation, energy storages, demand response, electric vehicles, …).
- **Platform for energy business activities**.
- **Monitoring of energy balance of LUT Green Campus**.

2.2. LUT Data Platform

The LUT data platform is among the key enablers of the agile research activities related to smart buildings and energy efficiency activities. The platform was initially launched 2010 to support research project but has since been iterated to serve large group of researchers in the LUT University campus. The present version of the data platform captures variety of data from multiple data sources, such as **solar PV (photo-voltaic) production**, **EV (electric vehicle) charging**, **other building energy sinks, multiple data sources from research activities on-site and remotely**.

[8] Mashlakov, A., Keski-Koukkari, A., Romanenko, A., Tikka, V., Jafary, P., Supponen, A., Markkula, J., Aro, M., Abdurafikov, R., Kulmala, A., Repo, S., Honkapuro, S., Järventausta, P., Partanen, J. Final report: Integrated business platform of distributed energy resources – HEILA, LUT Scientific and Expertise Publications, LUT University, Finland, 2019, 184 p.

The characteristics of the current implementation of the data platform can be summarized as follows:

- **Availability**
  - Easy access via GUI
  - API and UI to provide most efficient utilization of data
- **Governance/management**
  - Keeping policies, software, and hardware up to date
  - Ensuring future proof operation
- **Security**
  - Ensuring confidential data stays confidential
  - Single Sign-On (SSO) authentication and user management
- **Centralization**
  - Data access via single gateway/UI
  - Multiple parallel instances
    - Load balancing
    - Data replication, scalability
    - High availability
- **Realtime analysis**
  - Data pre-processing
  - Realtime analytics.

2.2.1. Technical implementation of the data platform

The data platform consists of three key elements.

The **core of the platform is the database cluster** that consists of **three independent InfluxDB Open Source**[9] **time series database instances on VPS (virtual private server) on LUT premises**. The **VPS** provides **Docker**[10] **engine service** to enable containerized service architecture. The **databases are replicated with near real-time replication agent** mostly implemented by the opensource resources.

[9] https://www.influxdata.com/products/editions/
[10] https://docs.docker.com/engine/

The **replication agent keeps data synced between database instances and ensures data integrity** if database instance is lost momentarily. Furthermore, **load balancing of the database instances is handled by the Round-robin DNS**[11] **configuration**.

The second key element of the data platform is **data collection and gateway service**. The data collection is implemented per service on Docker engine platform. In practice, **each collection script** or **gateway configuration is fully independent**, thus software bug or other incident on the single data collection component does not compromise of rest of the data collection components. The architecture also consists of **OpenVPN**[12] **gateway to enable integration of the remote data sources**.

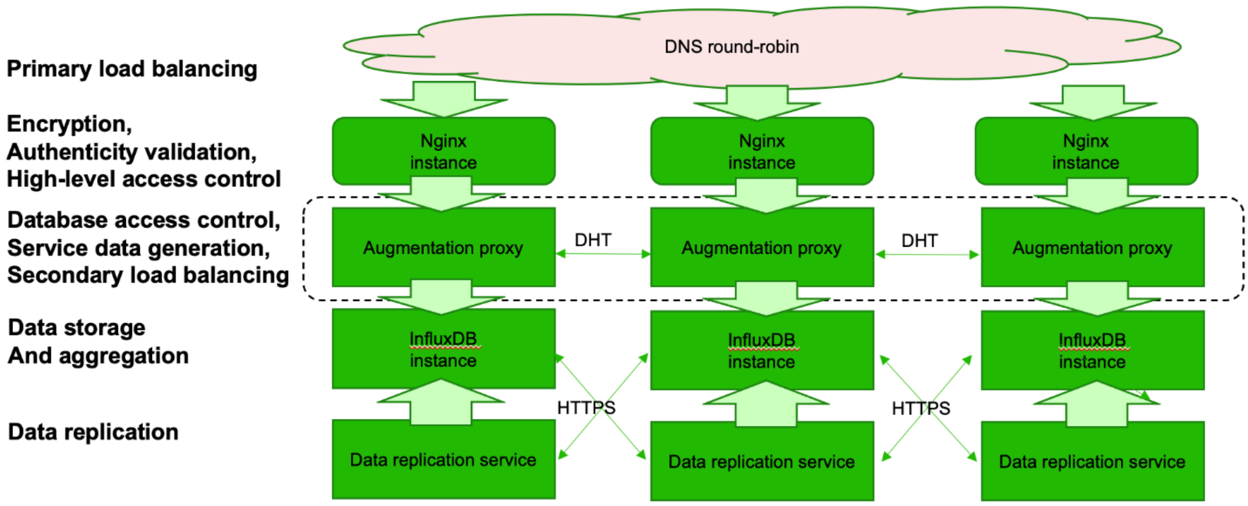

Fig. 6: The database cluster implementation of the LUT campus data platform.

The last and most visible component of the data platform is **UI (user interface)**. As the UI then VPS Docker engine runs **Grafana**[13] **docker image**. Then, UI has direct connection to the database cluster to enable near real-time visualization of the data feeds. The UI has Single Sign-On (SSO) authentication and user management to enable easy access for all staff members of the LUT university. **To maintain data integrity, UI has read-only access to database**.

[11] https://en.wikipedia.org/wiki/Round-robin_DNS
[12] https://centos.pkgs.org/7/okey-x86_64/openvpn-2.3.6-2.el7.centos.x86_64.rpm.html
[13] https://grafana.com/docs/grafana/latest/installation/docker/

2.2.2. User interface

The **Grafana UI is flexible visualization tool** that can be accessed with any modern web browser. Users can build complex visualization by utilizing **GUI** (graphical user interface).

UI also **enables data feed-based email alerting**. The alerts can be configured to trigger as certain threshold of data feed are exceeded or user can build complex indicators to trigger alerts.

The **UI can also be utilized to display statistics on public info screens**. The Figure 7 shows an simple example of the solar PV production statistics info screen.

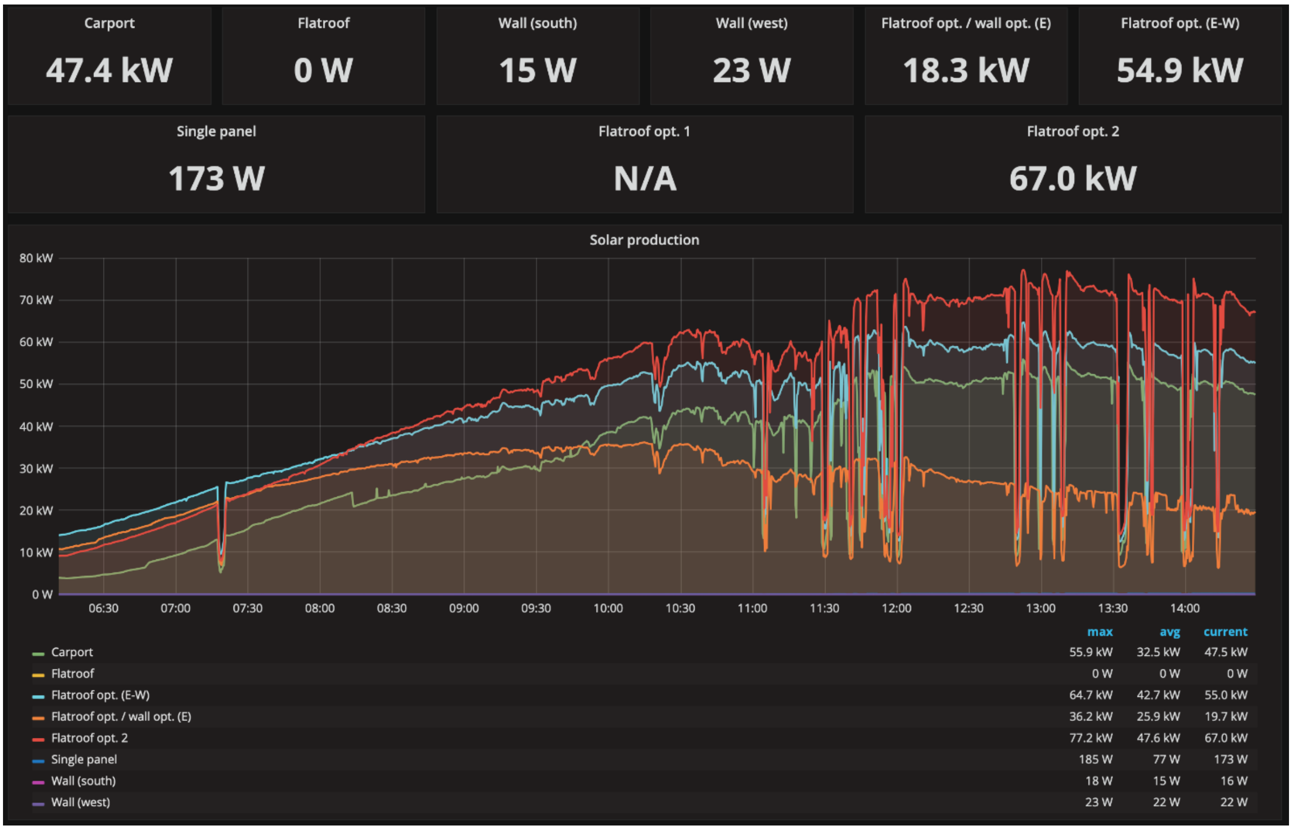

Fig. 7: Real-time solar PV monitoring info screen.

2.3. Actions towards carbon negativity

LUT University will strive for carbon negativity by the end of 2024. It is an ambitious goal, the achievement of which is monitored by the Greenhouse Gas Protocol.

LUT's own Sustainability Science Carbon Negativity Team, which is comprised by several experts from the university, calculates the carbon footprint annually. This calculations are based on **information collected from the university's units and stakeholders**. **LUT** is also **co-operating** with other **Finnish universities** to come up with common methodology for reporting carbon footprint and to set carbon neutrality targets for Finnish universities.

LUT's carbon footprint refers to climate (carbon dioxide) emissions caused by the activities of the organisation and its people. The **reported carbon footprint includes both direct and indirect emissions.** For example, cars owned by LUT cause direct emissions, while emissions from bought electricity and staff commuting are considered indirect.

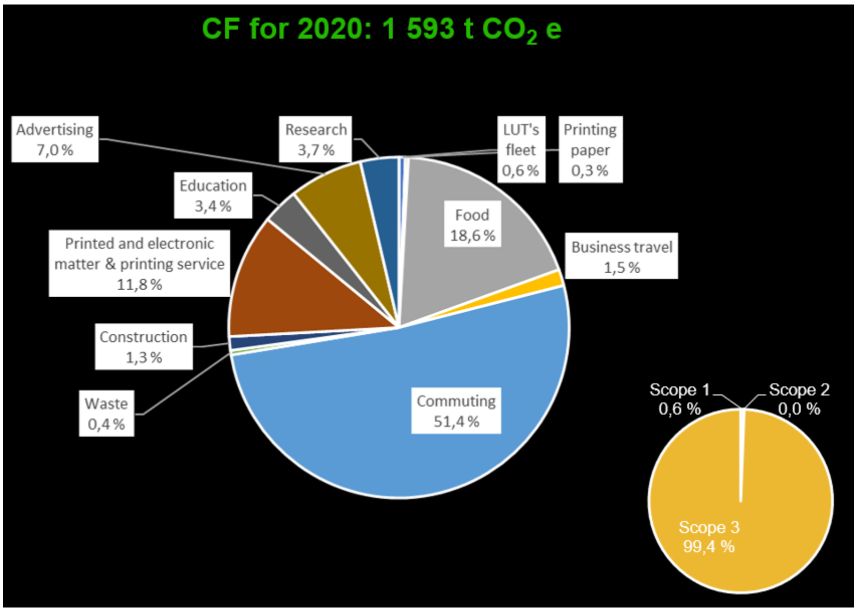

Fig. 8: LUT's Carbon Footprint in 2020

In **2020**, LUT's carbon footprint was 1,593 tons of carbon dioxide equivalent (CO2eq). Mobility accounted for 51.4 per cent of the emissions, while food was the second largest cause for emissions with 18.6 per cent.

LUT calculates its carbon footprint using the **Greenhouse Gas Protocol (GHG)**, which divides emissions into **three dimensions or scopes**. Scope 3, for example, includes district heating of a property. The calculations are used to analyse which emissions can be reduced and which needs to be compensated for.

To support decreasing the carbon footprint, a commuting survey was carried out in 2020: it was designed by the **Sustainability Science Carbon Negativity Team** to provide information about **transportation modes, commuting distance and a change in commuting patterns due to the COVID-19 pandemic**. The survey was sent via a university-wide email to all students and employees. With 1388 responses, 16% of students and 57% of employees responded to the commuting survey. Before the pandemic, 29 % of students studied remotely and about 15 % of staff worked from home. At the time of the survey (the end of 2020), **over half of those responded indicated that they have shifted to remote study/work, 55 % of the students and 59 % of the staff**.

Since the survey, a **new policy concerning remote working for the staff** has been introduced: in normal conditions staff is encouraged to work remotely up to 40 % of working time, if it's possible considering the working duties one has. **Increasing remote working decreases private commuting and emissions caused by this activity.**

The questionnaire observed only **slight differences in commuting mode shares arising from the pandemic**. The fraction of driving alone had slightly increased among students and employees during the pandemic. On the other hand, public transport use (bus and train) had decreased.

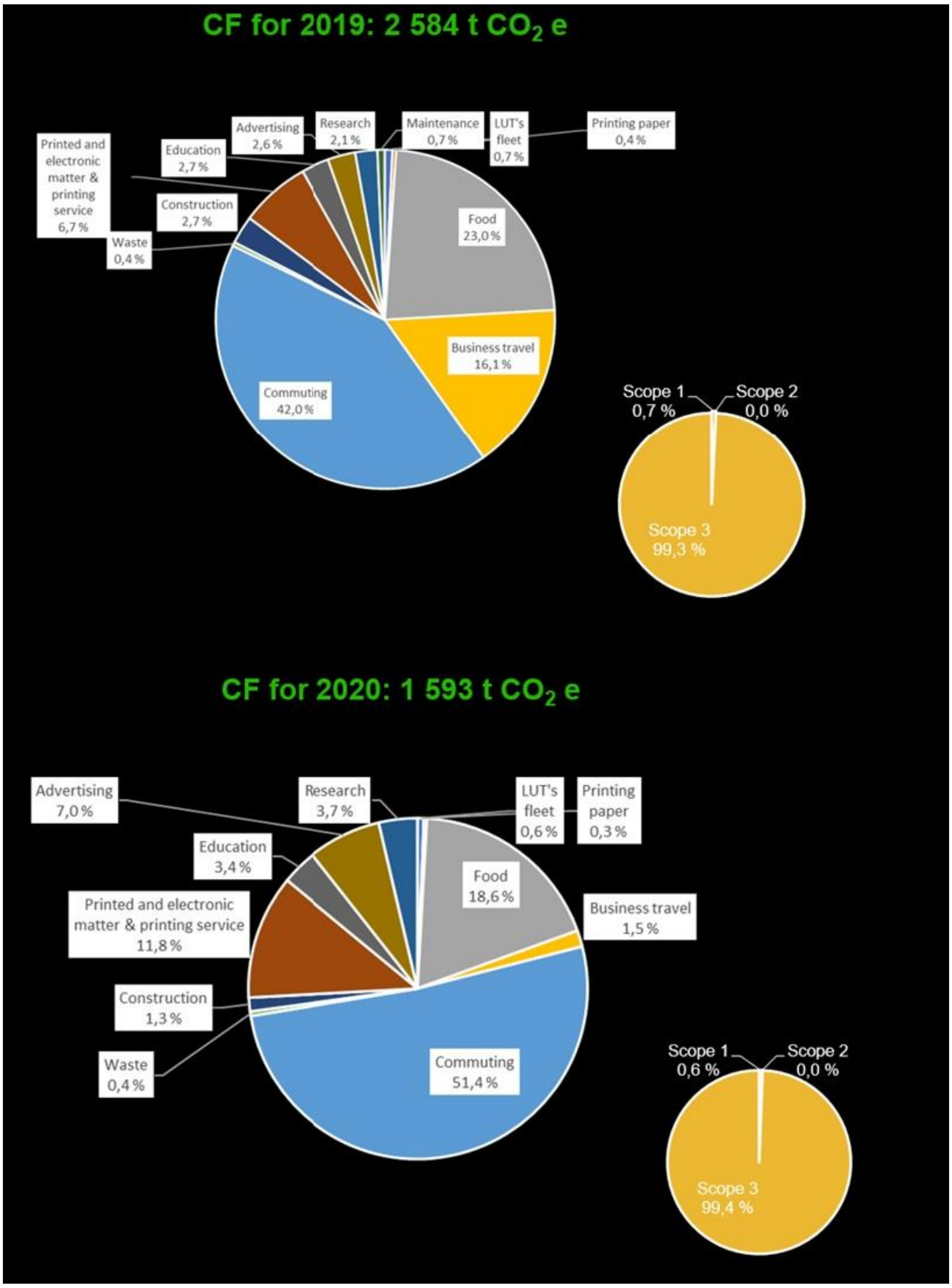

Fig. 9: LUT's Carbon Footprint 2019 ad 2020

In Fig. 10, the differences in commuting before and during the COVID-19 pandemic are presented.

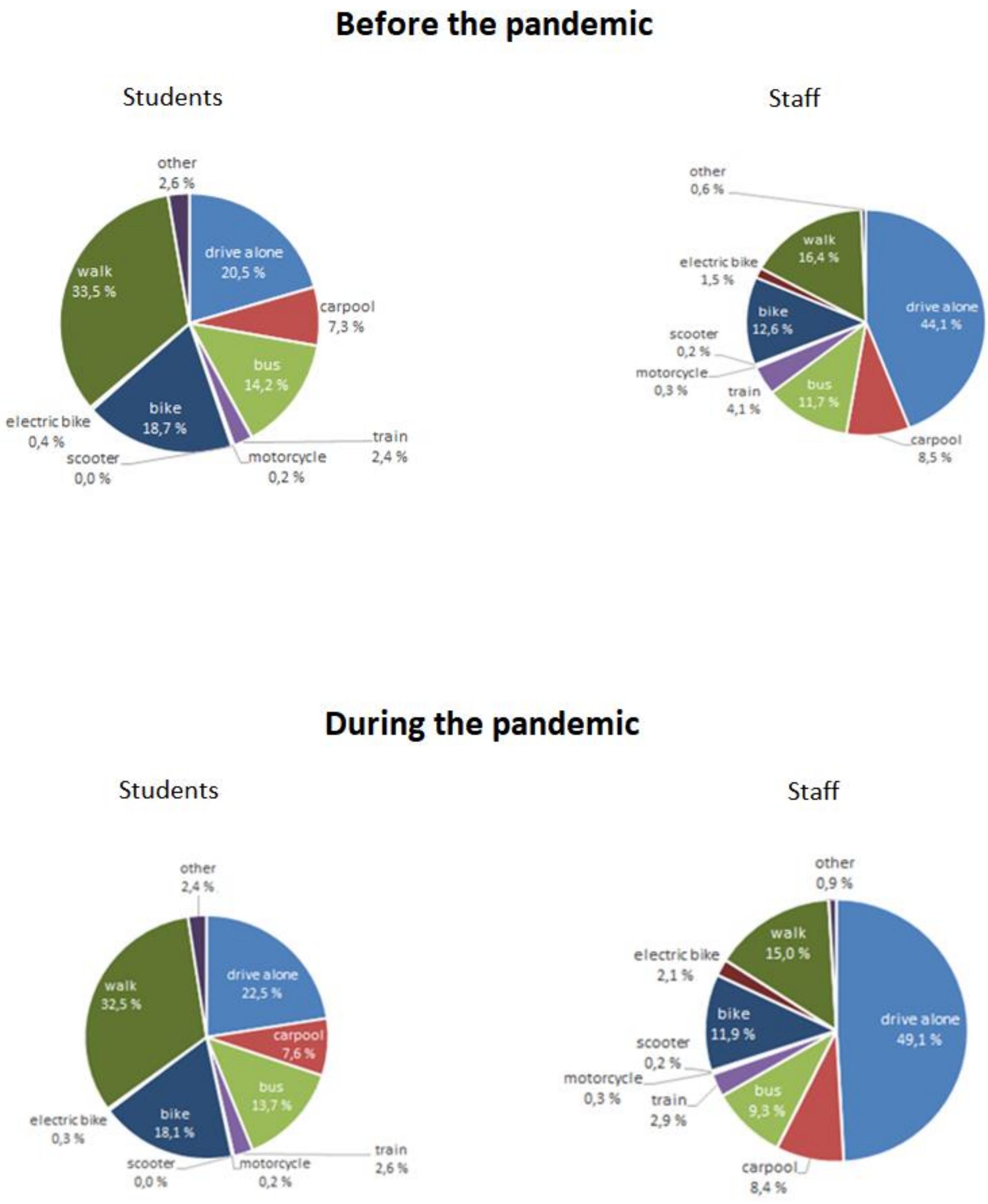

Fig. 10: Differences in commuting modes before and during the COVID-19 pandemic.

Annex 1

Self-Assessment Tool questionnaire

LUT University

S3UNICA Interreg Europe

European Union European Regional Development Fund

Draft ID: ebb0c505-b7ad-4b49-a1ba-68f2ac1cada3
Date: 25/11/2020 15:03:59

S3Unica - Interreg Europe Self Assessment Tool questionnaire

INTRODUCTION

S3UNICA project is based on the methodology adopted by the Smart Campus Interregional Innovation Pilot Action project which established a classification of partners' University Campuses and provided basic information about the dimension and the localization of technologies that have been adopted or are still in the testing phase. The main goal of the Smart Campus project was to develop the concept of smartness at University Campuses in the partnership regions: this should lead energy generation, distribution systems and energy use in university buildings in a more efficient and innovative way, in University Campus Buildings as far as technical, financial and planning aspects are concerned.

S3UNICA aims to:

- capitalize the experience gained by Smart Campus project partners (PPs);
- extend the acquired outputs to new PPs (Romania and Poland);
- develop a common vision based on the quadruple helix approach, according to Directive (EU) 2018 /844 of the European Parliament and of the Council of 30 May 2018 on the energy performance of buildings and the Smart Readiness Indicator, in order to improve policy instruments through the adoption of action plans

S3UNICA activities will be developed on the basis of the following 3 steps:

1. "**Identification and Analysis**": development of the self-assessment tool fist part enabling regional stakeholders to identify their strengths and weaknesses on the innovation cycle, policy framework, technical and financial performance;
2. "**Interregional mutual learning**": after the first step, S3UNICA will plan strategies, technical solutions, policy framework and ecosystem of the beneficiary region in order to increase smart energy saving, to improve distribution and production measures, as well as methods, resources, results and acquired experience throughout the innovation cycle;
3. "**Knowledge transfer and action plans**": given the lessons learnt from the Smart Campus project partners and considering the rich experience acquired by the new S3UNICA partners experienced, a common methodology will be drafted to support the growth of transnational markets by identifying action plans.

The assessment tool includes the above mentioned steps 1 and 2 and it will be implemented in two phases: The first phase will be approved during the first Steering Group (SG) and it is the subject of this document: it pursues the goal of collecting information in order to allow stakeholders to identify their strengths and weaknesses and of gathering quantitative data to build the next phase;

On the basis of the information received, the second phase will aim to define a common methodology to select technological roadmaps and the most appropriate policies.

The table below summarizes the implementation of the project activities:

	M0	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24
KARELIA										SG approve AT1															
ANDALUSIA																SG approves AT2									
[illegible] AT PP2, PP3				[illegible] identification and analysis							AT2port' tool' with Sn														
All Partners [illegible]											answers AT1port														
All Partners [illegible]																x	answers AT1port					x			
[illegible]																						SG analise report AT			

During the implementation of the assessment tool, the LP will capitalize on the previous experiences acquired in the management of European projects, such as SMART CAMPUS and CEEM (project financed by the Central Europe Program through ERDF funds which aimed to provide SMEs with environmentally friendly technologies, operating methods, good practices and an IT tool to self-evaluate their performance), in order to achieve the following objectives of the S3UNICA project:

- collection of information provided by Universities stakeholders and consequent sharing with other stakeholders during the RSM to create suitable conditions for involving new private actors and for promoting the use of public-private partnership (PPP) and public private procurement instruments;
- Identification of at least 20 good practices;
- Drafting of the "Technology and Policy Road Map", selecting promising technologies and smart energy management systems;
- Drafting of 5 action plans to enhance regional policy instruments.

The first part of the assessment tool is structured as a survey, subdivided into four sections:

1. **POLICY SECTION**: it concerns the collection of information to monitor the current state of the policies implemented by the PPs in order to achieve energy efficiency on University campuses buildings and infrastructures;
2. **FINANCIAL SECTION**: on the basis of the data provided by the partners, it allows to check the availability of financial instruments aimed at implementing energy efficiency interventions on University campuses;
3. **TECHNICAL SECTION**: (a) it collects general information concerning University campuses buildings and infrastructures; (b) it reports the matrix of information necessary to the application of the SRI methodology, identifying the questionnaire for the collection of information related to row 1. **"Monitori ng and measurement"** and row (2.) **"Technical solutions"**;
4. **ENERGY EFFICIENCY, FUTURE SCENARIOS AND VISION**: it is requested on one hand, a self-assessment of the energy performance detected in campuses analyzing the obstacles encountered and the extent of the energy efficiency of the measures adopted, on the other hand it is requested the indication of the objectives of the political actions undertaken at various levels.

POLICY SECTION

[To be completed by PP and University]

In order to understand the situation of the regulations supporting energy efficiency on university campuses, the following information is required from the partners, therefore the following questions need an answer from the single partner.

Are there policy[1] measures at any level (local, national) encouraging the **development of nZEB university buildings?** What has been already done and what results were achieved? Please give some examples.

[1] A policy is a principle or protocol to guide decisions and achieve rational outcomes, defined by political agreement at local/national/EU levels and adopted by law);

1000 character(s) maximum

All new buildings shall be constructed as nearly zero energy buildings from the beginning of 2021. The same requirements have been in effect since the beginning of 2019 for buildings used or owned by the authorities.

There have been several upgrades on the national building code to promote energy efficiency since 2008.

Are there policy measures at any level (local, national) for encouraging the adoption of **smart monitoring and control systems?** What has been already done and what results were achieved? Please give some examples.

1000 character(s) maximum

Virtually all energy electricity consumption meters in Finland have been upgraded to remotely readable.

Are there policy measures at any level (local, national) for encouraging an **integrated energy management system for university/public buildings?** What has been already done and what results were achieved? Please give some examples.

1000 character(s) maximum

Integrated energy management systems are voluntary. However, it makes sense to have central energy management system in larger buildings, since it will earn savings in energy consumption and costs. Several campuses in Finland, including LUT University, utilize energy manager services, which are based on intensive monitoring of energy and water consumption.

Are there **self-implemented[1] energy efficiency policies** in place, not part of mandatory policies? What has been already done and what results were achieved? Please give some examples.

[1] Specify if the university campus has implemented additional policy regulations not mandatory requested by the regional-national-EU levels);

1000 character(s) maximum

LUT University is committed to making its campuses in Lappeenranta and Lahti carbon negative by 2024. Continuous improving of energy efficiency, along with increasing the efficiency in water consumption and waste management, is included in the carbon negativity target. A data platform for research purposes has been opened for the staff to explore the possibilities to improve energy efficiency, by developing novel algorithms for building systems using actual measured data from the campus.

LUT achievements: The operational carbon dioxide emissions decrease in the period 2016-2018 was 17 %. Significant decreases in energy and water consumption, and waste amounts, have been achieved since 2012.

Does your university campus **adhere to mandatory energy policies at any level** (local, national, EU)? If yes, please specify.

1000 character(s) maximum

LUT University has chosen to take the role of a forerunner in sustainability and energy efficiency, therefore the targets and measures are aimed higher than the mandatory basic requirements.

Are there **measurable objectives or targets achieved or to be achieved by your university campus?** Please specify if the campus has set up/achieved targets and objectives, both quantitative (e.g. numbers to be achieved) or qualitative (e.g. general final objectives expressed in a to-do-list levels).

1000 character(s) maximum

Continuous improving of energy efficiency, along with increasing the efficiency in water consumption and waste management, is included in the carbon negativity target.

Which policies have been implemented at local/regional national level or at campus level to promote the energy efficiency sector (i.e. development of innovative solutions, collaboration with private companies, support for the creation of universities spin-offs/start-ups to commercialize these new technologies, promotion of the interregional collaboration and projects at European level)? Please give some examples.

1000 character(s) maximum

What are the bottlenecks you have experienced with regard to the energy efficiency policy implementation?

1000 character(s) maximum

In the context of renovations, it is difficult to get novel suggestions through – even when they are based on robust technologies. Players involved (building owners, designers, contractors) tend to have conservative opinions on what could be achieved with better systems. In addition, they ofter lack the experience of including new elements to buildings. Therefore, it' easier to claim that "It's not feasible".

Being S3 an "ex ante " conditionality to access cohesion funds, S3Unica project will contribute to influence regional policy, starting from University achievements. Has your university contributed to the definition of your Regional S3/ development trajectories ? Or has your Unviersity benefited from existing S3 (i.e. energy related projects funded through ERDF)?

1000 character(s) maximum

LUT university element is a key actor in the regional innovation ecosystem. The Regional Innovation Strategy of South Karelia (RIS3) is well aligned with the strategic priorities of the university. LUT as an organisation, also through its experts and regional networks has been involved in the smart specialisation strategy process and the entrepreneurial discovery process. "Clean energy" is one of the regional smart specialisation key themes and the LUT is the leading energy research university in Finland. Hence the university is leading and partnering in most ERDF funded energy related projects.

FINANCIAL SECTION

[To be completed by PP and University]

To understand the availability of financial instruments for the implementation of energy efficiency interventions on university campuses, each single partner should provide the following information.
Are the following financial instruments available?

Energy Performance Contract;

1000 character(s) maximum

Not recognised.

Mortgages for energy efficiency/Bank loans;

1000 character(s) maximum

Not recognised.

State Incentives dedicated to Universities;

1000 character(s) maximum

Not recognised.

National programs dedicated to energy efficiency works for public buildings;

1000 character(s) maximum

Not recognised.

Dedicated credit institutions/bodies (EE funds) for energy efficiency works/Investments;

1000 character(s) maximum

Not recognised.

Other financial systems or initiatives: specify

1000 character(s) maximum

Not recognised.

Which financial schemes have been implemented to promote policies in the energy sector (i.e. development of innovative solutions, collaboration with private companies, support for the creation of universities spin-offs/start-ups to commercialize these new technologies, promotion of the interregional collaboration and projects at European level)? Please give some examples.

1000 character(s) maximum

Regional development funds (for public sector organisations, SME companies) from national and EU sources, competitive RDI funding on national level (e.g. Business Finland, Academy of Finland) and EU level (Horizon 2020).

TECHNICAL SECTION

[To be completed by University]

The following answers are required from the stakeholders (campuses) to collect general information within university campuses and to understand the technological state of the buildings:

In this section Identification information, status and size of campuses are collected

	Question Description
University Name	Lappeenranta–Lahti University of Technology LUT
Country	Finland
City	Lappeenranta
ZIP code	53850
Street name Number	Yliopistonkatu 34
Description of the campus *[Insert a short and clear description of the campus: buildings (single or group of buildings, modern or historical), activities carried out (teaching rooms, labs, auditorium, offices, hospitals, sports facilities,...) (max. 1000 characters).]*	LUT University's Lappeenranta Campus consist of 7 buildings / buildings phases.
Campus ownership *[Property is the state of full possession of the assets used by the University. Rent is the state of contractual duty of these assets with an external owner.]*	Building phases 1–5 and 7 are leased from Suomen yliopistokiinteistöt Oy (SYK Ltd; University Properties of Finland Ltd). SYK is owned by nine universities outside the Helsinki metropolitan area and the Finnish State. The Finnish State is represented by Senate Properties. LUT University's share is 3,23 %. Building phase 6 is owned by Lappeenrannan Tieto-Sähkötalo Oy, which is a company founded to maintain the building operations for building 6. LUT staff has a strong repsentation in the board.
Location *[Specify if the University is located in a fully independent building or if it is shared. Specify if the buildings are isolated or integrated into a district with other activities, or if they are included like the other civil residences in the city]*	LUT buildings are located at the same site. However, there are also other activities inside the campus. Building phase 4, which is physically connected to the main campus, operates as a temporary facilities for a preschool and primary school, serving approximately, serving approximately 260. Also, the LAB University of Applied Sciences is operating at the same site. It is not included in this context.

Number of employees *[Indicate the number of students, lecturers, researchers, technicians, other staff present daily in buildings (reference: year 2019)]*	Number of undergraduate and postgraduate students: approx. 5200 Approx. 80 different nationalities Number of students in continuing education: approx. 140 Number of students in the Open University: approx. 400 Total staff: 926 Academic staff: 556
Area [m^2] *[Indicative value. Specify the net floor area occupied by the buildings, taking into account all features allocated (offices, teaching rooms, etc).]*	Building phase 1: 22000 m2; Building phase 2: 12826 m2; Building phase 3: 8388 m2; Building phase 4: 5136 m2; Building phase 7: 8741 m2; Tietosähkötalo: 4300 m2 Total floor area: 61 392 m2. The information for breakdown of floor areas for different functions (offices, teaching etc.) was not yet available. This can be updated later during the S3UNICA project.
Volume [m^3] *[Indicative value. Specify the net volume of the campus, taking into account all features allocated (offices, teaching rooms, etc).]*	NA

In this section detailed information about different energy sources, final energy usage, consumption behavior, building structure, planned and adopted measures will be collected

	ABILITY TO MAINTAIN ENERGY PERFORMANCE AND OPERATION	ABILITY TO REPORT ON ENERGY USE	ADAPT ITS OPERATION MODE IN RESPONSE TO THE NEEDS OF THE OCCUPANT	MAINTAINING HEALTHY INDOOR CLIMATE CONDITIONS	FLEXIBILITY OF A BUILDING'S OVERALL ENERGY DEMAND
MONITORING AND MEASUREMENT	Sufficient ability to maintain desired temperature, lighting and comfort conditions.	Monthly energy consumption and CO2 emission reports from the energy manager.	Sensors (mainly temperature, in some cases CO2) connected to control systems.	Continuous monitoring and adjustment of temperature, air flow and humidity.	Technical readiness for electricity and district heating demand response.
TECHNICAL SOLUTIONS	Heating and DHW energy demand are fulfilled with district heating supply. Cooling demand is fulfilled with heat pump technology. Heat recovery is applied in the AC systems.	Energy flow meters, heating and ventilation supply temperature measurement devices, current data and history logging. The energy manager has access to all measurements.	Adjustable temperature thermostats on room level. Presence sensors in hallway lighting systems.	Cooling with ventilation system during warm periods, sufficient to keep temperature under national guidelines.	Solar electric panels installed on multiple buildings, technical readiness for electricity use flexibility.

	ABILITY TO MAINTAIN ENERGY PERFORMANCE AND OPERATION	ABILITY TO REPORT ON ENERGY USE	ADAPT ITS OPERATION MODE IN RESPONSE TO THE NEEDS OF THE OCCUPANT	MAINTAINING HEALTHY INDOOR CLIMATE CONDITIONS	FLEXIBILITY OF A BUILDING'S OVERALL ENERGY DEMAND
MONITORING AND MEASUREMENT	Quality of the measure (entire building, single thermal zone, single service for example: lighting, air conditioning, other services	Frequency of measurements (annual, monthly, weekly); Quality of energy consumption measurement (system of buildings single building, single service for example: lighting, air conditioning, driving force);	Quality of the measure (system of buildings , building, single service for example: lighting, air conditioning, driving force) of temperature, relative humidity, CO_2 rate; lighting;	Quality of the measure (entire building, single service for example: lighting, air conditioning, driving force) of temperature, relative humidity, CO_2 rate;	Availability of system to monitor energy demand and local energy ailability (in direct or mulated production);
	A	B	C	D	E
TECHNICAL SOLUTIONS	Supply capacity of thermal and cooling energy for system of buildings, single building or single thermal zone;		Supply capacity of thermal and cooling energy and adjustment of air changes depending on the needs of the occupants in the single areas;	Supply capacity of thermal and cooling energy and adjustment of air changes depending on the needs in the single areas;	Presence of energy production from renewable sources (Photovoltaic, geothermal, solar thermal); Availability of electrical energy storage; Availability of thermal energy storage; Ability to supply the necessary energy through the purchase of energy or local production from renewable sources or, also, through the integration with other availability in the territory (e.g. waste heat)

Monitoring and measurement:

	A
Is there a dedicated office or person for energy management? *[Specify.]*	Energy manager reports on monthly basis on energy and water consumption. The contract is based on increasing energy efficiency year-by-year. The building systems are operated and maintained by another company, in cooperation with the energy manager.
Is there a Building Management System (BMS) implemented? *[A Building Management System (BMS) is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems]*	Yes, a central Building Management System (BMS) is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems.
Data Collection *[Specify. which quantities are measured (e.g.energy consumption, temperature, relative humidity, CO2 rate); indicate if the measurement is aggregated (for whole campus, single building, building zone) or single service (example.; lighting, air conditioning; thermal energy, driving force); for each of them give the measurement frequency (e.g. annual, monthly) weekly).]*	Energy manager monitores LUT University's energy consumption (district heating, electricity) and water consumption, and reports monthly energy consumption, water consumption and CO2 emissions. LUT University has established a data platform for research purposes. Energy and related measurements (tempratures, air flows etc.) will be connected to the platform in near future.
Energy flow measurements *[Specify if this specific action is performed on campus and if it is implemented in the BMS]*	Included in the energy manager's contract.
Energy cost analysis *[Specify if this specific action is performed on campus and if it is implemented in the BMS]*	Included in the energy manager's contract.
Emission measurement *[Specify if this specific action is performed on campus and if it is implemented in the BMS]*	Included in the energy manager's contract.
Other measurements *[Specify.]*	Included in the energy manager's contract (water consumption).
Was an indoor air quality test ever conducted in the building? *[Specify.]*	NA
Did customers or employers ever report thermal comfort dissatisfaction? *[Specify.]*	NA

Technical solutions

	A
Main Source for Electrical Power *[Specify which is the main source for electrical power used within the campus]*	Local/national electricity grid.
Additional Relevant Source for Electrical Power *[Specify if you are using an additional relevant source for electrical power in your university]*	Solar panels, approx. 500 kVA.
Type of Supply Electrical Energy Contract *[Answer "metered" if you receive a bill from the utility company. Alternatively specify other methods]*	Metered.
Yearly Electrical Energy Consumption [kWh] (reference year 2019) *[Fill in the value of the electric energy consumption of one year]*	6 636 MWh (2019); CO2 emissions: 0 tCO2/a (2019; Green electricity contract)
Yearly Electrical Energy Cost *[Fill in the value for the total energy cost of one year of activities]*	NA
Main Source for Space Heating *[Specify the main source for space heating in the buildings]*	District heating.
Main Fuel Type *[Specify the main fuel type used by your company]*	Lappeenranta Energy company's DH fuel composition in 2019: Biofuels: 67,4 % Peat: 14,9 % Natural Gas: 12,9 % Secondary heat from industry: 4,9 % CO2 emissions: 91 g/kWh (Finnish national average: 130 g/kWh)
Yearly main fuel Consumption (referred year: 2019) *[Fill in the value for your total energy consumption of one year of operation and specify the reference unit for the specific fuel]*	DH consumption: 6 951 MWh (2019); CO2 emissions: 652 tCO2/a (2019). Average fuel consumption: see above.
Yearly main fuel Cost *[Fill in the value for the total energy cost of one year of activities.]*	NA
Main heating Conversion Technology *[Specify which is the main conversion technology for space heating]*	District heating.
Main Heating Distribution Technology *[Specify the main distribution technology for space heat]*	Central water heating.

Main Source for Space Cooling *[Specify which is the main source for buildings cooling]*	Mainly through central Air Conditioning systems.
Main Cooling Conversion Technology *[Specify which is the main conversion technology for space cooling]*	Cooling coil installed to the AC system.
Main Cooling Distribution Technology *[Specify the main distribution technology for space cooling]*	Via ventilation systems.
Additional relevant Fuels Type *[Specify if the University utilizes an additional relevant fuel type beside the main fuel type stated before]*	-
Type of additional fuels Supply Contract *[Answer "metered" if you receive a bill from the utility company. Alternatively specify other methods]*	-
Yearly additional fuel Consumption (reference year: 2019) *[Fill in the value for your total energy consumption of one year of operation and specify the reference unit for the specific fuel]*	-
Is there an on-site or off-site renewable energy system installed? *[Specify if the Campus has installed an energy system based on renewable sources (e.g. solar, biomass, wind, geothermal, hydro)]*	Solar power plant, on-site.
Which kinds of renewable energy systems are installed? *[Select the proper system(s)]*	Solar power plant, 500 kVA.
Percentage of Electrical Energy Consumption from Renewable Sources *[Specify the range of electrical energy consumption from renewable resources according to the overall electrical energy consumption in your campus]*	100 % by electricity contract (Green electricity).
Percentage of Thermal Energy Consumption from Renewable Sources *[Specify the range of thermal energy consumption from renewable resources according to the overall thermal energy consumption in your campus]*	District heating: 72 % (2019)
Renewable Electric Energy Self-Consumption [%] *[Specify percentage of self-consumed renewable electrical energy according to the total self-produced renewable electrical energy]*	Appr. 7 % (2019)
Renewable Energy Systems Added Value [€] *[Specify the approximative added value in euros per year obtained from renewable energy systems installed by your campus, as a sum of both energy discounts and feed-in tariff]*	NA

Can you quantify approximately the overall savings achieved [%]? *[Indicate the approximate percentage for improvements yet achieved by the university after above selected measures have been taken]*	NA
Is there any additional potential for improvement in terms of energy efficiency? *[Specify if you consider that the University has a relevant potential for improving the energy efficiency at any level of building, indoor, lab]*	In general, the situation is good. Monitoring energy efficiency is included in the energy manager's contract.
Is there any additional potential for improvement in terms of energy efficiency? *[Estimate the approximate percentage of improvements that could be achieved by the university through additional energy efficiency measures]*	In general, the situation is good. Monitoring energy efficiency is included in the energy manager's contract.
Is there any innovative technologies/solutions developed by the University for improvement of energy efficiency and environment? *[To describe other innovative solutions that are being developed by the University or even implemented at the testing level.]*	LUT has spawned a number of patents and spin-offs related to energy efficiency.
Are there any innovative solutions developed at your University that need a scale up from TRL 5 to TRL9? *[[NOTE] The idea of the Smart Campus project was to foster the interregional collaboration to promote innovation in the Universities Campuses, supporting innovative technologies to advance them from TRL 6 to TRL 8 or 9 through the collaboration between different universities. One of the conclusions of the Smart Campus project was the need to enlarge the portfolio of innovative solutions.]*	Not recognized.
If yes, what are the main bottlenecks you face for the scaling up? *[]*	-

ENERGY EFFICIENCY, FUTURE SCENARIOS AND VISION SECTION

[To be completed by University]

In this section both a self-assessment of campus performance (in accordance with the barriers, obstacles and relevance of energy efficiency) and targets at various levels of policy actions is required.

Relevance of energy efficiency, future outlook and Vision:

	A
Impact of energy efficiency measures during last three years? *[Specify if the university is considering to receive back a positive impact from energy efficient measures adopted in last three years (1 means not receiving any positive impact, 5 means very high positive impact).]*	4, considering that there already has been an intensive trail of improvement since 2012.
Did you find obstacles on energy efficiency measures and their implementation? *[Specify, whenever the university has had some obstacles, in implementing EE measures]*	The easiest improvements have already been done, it gets more and more challenging to improve year-by-year.
Have you been able to overcome obstacles on energy efficiency measures and their implementation? *[Specify, whenever the university has had some obstacles, if it has been able to overcome them and correctly implement target actions]*	Nothing specific, since energy efficiency is part of the university's strategy.
No idea of energy efficient measures *[Rate the relevance of this obstacle or barrier for the university energy efficiency either on the basis of your direct experience or according to your knowledge of the field (give a score between 1 and 5, 1 means small obstacle or low relevance, 5 means big obstacle or high relevance)]*	1.
Time and staff resources in the company *[See above]*	1. The LUT School of Energy Systems (LES) is the largest university-level energy research and education community in Finland. More than 300 experts work every day in energy-related research and teaching, 80 of which have a Ph.D. Research at LES is profiled with a strong systems-based nature, involving the entire energy value chain from fuels /resources, through generation/transmission/distribution and to the use of energy, including technologies, devices, market design, business models, policies, resource efficiency and sustainability.
External support (technical or economic) *[See above]*	3. More Energy efficiency pilot projects could be carried out with more external funding.

Financial issues: Absence of dedicated budget for improvement of energy efficiency *[See above]*	1. Energy efficiency measures go together with other campus investments and are included in building owner's (SYK) overall investment programs. However, specific projects can be carried out with external funding, as research pilot projects or such.
Long pay-back period for possible projects *[See above]*	2. Not a big problem in pilot projects. The building systems operate on commercial level.
Others obstacles *[Specify]*	-
Which are the obstacles for the development/application of innovative technologies/solutions developed by the University (if any) for improvement of energy efficiency? *[on the basis of your direct experience specify the bottlenecks of innovative solutions that are being developed by the University or even implemented at the testing level]*	Normal obstacles: how to develop a product/service for a market that is not ready for the innovation yet?
Have you planned to implement (additional) energy efficiency policies in your university? *[Specify an already planned intention to implement energy efficiency measures in the University.]*	Carbon negativity project: action plan is currently under construction.
In which time framework *[Indicate the time horizon of eventually planned actions to be implemented by the university in the next future]*	Carbon negativity project: actions will be in use by the end of 2024.
Which reduction in overall energy consumption is expected? *[Indicate the percentage of expected reduction in energy consumption expected from the planned actions to be implemented by the university in the next future]*	A moderate decrease in energy consumption year-by-year is to be expected. Since 2012, tens of percents (for example: 26 % in heat energy consumption; 24 % in electricity consumption 2012 – 2016) improvements have already been achieved.
Which reduction of fossil fuels is expected? *[Indicate the percentage of expected reduction in energy from fossil fuels expected from the planned actions to be implemented by the university in the next future]*	LUT has used Green electricity (100 % renewable) since 2014. This year, the local District Heating Company launched a Green District Heat product. It has been produced from different biomass sources. Hence, it is expected that in the very near future, no fossil fuels will be used to produce any energy LUT purchases.

What is the "energy culture" spread at your university campus? (i.e. do students know about campus energy savings goals, is there any piece of information on this,...) *[Specify]*	LUT is very energy oriented university, sustainability is in the core of the university – in both research and teaching.

Annex 2

Smart Readiness Indicator

Domain	Theme	Code	Service group	Smart ready service	Functionality level 0 (as non-smart default)	Functionality level 1	Functionality level 2	Functionality level 3	Functionality level 4	part of the proposed simplified indicator	Preconditions / Dependency on other services or building types	Functionality level	
Heating	Controllability of Performance: Emission	Heating-S1	Heat control - demand side	Heat emission control	No automatic control	Central automatic control (e.g. central thermostat)	Individual room control (e.g. thermostatic valves, or electronic controller)	Individual room control with communication between controllers and to BACS	Individual room control with communication and presence control	1	Always to be assessed (if domain is relevant)	2	Level 2
Heating	Controllability of Performance: Production	Heating-S2a	Control heat production facilities	Heat generator control (all except heat pumps)	Constant temperature control	Variable temperature control depending on outdoor temperature	Variable temperature control depending on the load (e.g. depending on supply water temperature set point)			1	Not applicable to heat pumps	2	Level 2
Heating	Controllability of Performance: Production	Heating-S2b	Control heat production facilities	Heat generator control (heat pumps)	On/Off-control of heat generator	Multi-stage control of heat generator capacity depending on the load or demand (e.g. on/off of several compressors)	Variable control of heat generator capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control)	Variable control of heat generator capacity depending on the load AND external signals from grid		1	Only applicable in case of a heat pump	3	Level 3
Heating	Storage & Connectivity	Heating-S3	Control heat production facilities	Storage and shifting of thermal energy	None	HW storage vessels available	HW storage vessels controlled based on external signals (from BACS or grid)			1	Only applicable if storage is present	0	Level 0
Heating	Reporting functionalities	Heating-S4	Information to occupants and facility management	Report information regarding heating system performance	None	Central or remote reporting of current performance KPIs (e.g. temperatures, submetering energy usage)	Central or remote reporting of current performance KPIs and historical data	Central or remote reporting of performance evaluation including forecasting and/or benchmarking	Central or remote reporting of performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection	1	Always to be assessed (if domain is relevant)	4	Level 4

Domain	Theme	Code	Service group	Smart ready service	Functionality level 0 (as non-smart default)	Functionality level 1	Functionality level 2	Functionality level 3	Functionality level 4	part of the proposed simplified indicator	Preconditions / Dependency on other services or building types	Functionality level	
Domestic hot water	Controllability of Performance	DHW-S1	Control DHW production facilities	Control of DHW storage charging (with direct electric heating or integrated electric heat pump)	Automatic control on / off	Automatic control on / off and scheduled charging enable	Automatic on/off control, scheduled charging enable and demand-based supply temperature control or multi-sensor storage management			1	Only applicable in case of DHW storage with electric heating	0	Level 0
Domestic hot water	Storage & Connectivity	DHW-S2	Flexibility DHW production facilities	Control of DHW storage charging	None	HW storage vessels available	Automatic charging control based on local availability of renewables or information from electricity grid (DR, DSM)			1	Only applicable if storage is present	0	Level 0
Domestic hot water	Information to occupants	DHW-S3	Information to occupants and facility managers	Report information regarding domestic hot water performance	None	Indication of actual values (e.g. temperatures, submetering energy usage)	Actual values and historical data	Performance evaluation including forecasting and/or benchmarking	Performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection	1	Always to be assessed (if domain is relevant)	4	Level 4
Cooling	Controllability of Performance: Emission	Cooling-S1	Cooling control - demand side	Cooling emission control	No automatic control	Central automatic control (e.g. central thermostat)	Individual room control (e.g. thermostatic valves, or electronic controller)	Individual room control with communication between controllers and to BACS	Individual room control with communication and occupancy detection	1	Always to be assessed (if domain is relevant)	3	Level 3
Cooling	Controllability of Performance: Production	Cooling-S2	Control cooling production facilities	Generator control for cooling	On/Off-control of cooling production	Multi-stage control of cooling production capacity depending on the load or demand (e.g. on/off of several compressors)	Variable control of cooling production capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control)	Variable control of cooling production capacity depending on the load AND external signals from grid		1	Always to be assessed (if domain is relevant)	2	Level 2
Cooling	Storage & Connectivity	Cooling-S3	Flexibility and grid interaction	Flexibility and grid interaction	No automatic control	Scheduled operation of cooling system	Self-learning optimal control of cooling system	Cooling system capable of flexible control through grid signals (e.g. DSM)	Optimized control of cooling system based on local predictions and grid signals (e.g. through model predictive	1	Only applicable if storage is present	3	Level 3
Cooling	Reporting functionalities	Cooling-S4	Information to occupants and facility managers	Report information regarding cooling system performance	None	Central or remote reporting of current performance KPIs (e.g. temperatures, submetering energy usage)	Central or remote reporting of current performance KPIs and historical data	Central or remote reporting of performance evaluation including forecasting and/or benchmarking	Central or remote reporting of performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection	1	Always to be assessed (if domain is relevant)	3	Level 3

Domain	Theme	Code	Service group	Smart ready service	Functionality level 0 (as non-smart default)	Functionality level 1	Functionality level 2	Functionality level 3	Functionality level 4	part of the proposed simplified indicator	Preconditions / Dependency on other services or building types	Functionality level	
Controlled ventilation	Controllability of Performance	Ventilation-S1	Air flow control	Supply air flow control at the room level	No ventilation system or manual control	Clock control	Occupancy detection control	Central Demand Control based on air quality sensors (CO2, VOC,...)	Local Demand Control based on air quality sensors (CO2, VOC,...) with local flow from/to the zone regulated by dampers	1	Always to be assessed (if domain is relevant)	4	Level 4
Controlled ventilation	Reporting functionalities	Ventilation-S3	Feedback - Reporting information	Reporting information regarding IAQ	None	Air quality sensors (e.g. CO2) and real time autonomous monitoring	Real time monitoring & historical information of IAQ available to occupants	Real time monitoring & historical information of IAQ available to occupants + warning on maintenance needs or occupant actions (e.g. window		1	Always to be assessed (if domain is relevant)	2	Level 2
Lighting	Controllability of Performance	Lighting-S1	Artificial lighting control	Occupancy control for indoor lighting	Manual on/off switch	Manual on/off switch + additional sweeping extinction signal	Automatic detection (auto on / dimmed or auto off)	Automatic detection (manual on / dimmed or auto off)		1	Always to be assessed (if domain is relevant)	3	Level 3
Dynamic building envelope	Controllability of Performance	DE-S1	Window control	Window solar shading control	No sun shading or only manual operation	Motorized operation with manual control	Motorized operation with automatic control based on sensor data	Combined light/blind/HVAC control	Predictive blind control (e.g. based on weather forecast)	1	Only applicable in case movable shades, screens or blinds are present	1	Level 1
Dynamic building envelope	Reporting functionalities	DE-S3	Feedback - Reporting information	Reporting information regarding performance	No reporting	Position of each product & fault detection	Position of each product, fault detection & predictive maintenance	Position of each product, fault detection, predictive maintenance, real-time sensor data (wind, lux, temperature...)	Position of each product, fault detection, predictive maintenance, real-time & historical sensor data (wind, lux, temperature...)	1	Only applicable in case movable shades, screens or blinds are present	0	Level 0

Domain	Theme	Code	Service group	Smart ready service	Functionality level 0 (as non-smart default)	Functionality level 1	Functionality level 2	Functionality level 3	Functionality level 4	part of the proposed simplified indicator	Preconditions / Dependency on other services or building types	Functionality level	
Electricity	Storage & Connectivity	Electricity-S1	Storage	Storage of (locally generated) electricity	None	On site storage of electricity (e.g. electric battery)	On site storage of energy (e.g. electric battery or thermal storage) with controller based on grid signals	On site storage of energy (e.g. electric battery or thermal storage) with controller optimising the use of locally generated electricity	On site storage of energy (e.g. electric battery or thermal storage) with controller optimising the use of locally generated electricity and possibility to feed back into the	1	Only applicable in case of local energy generation	0	Level 0
Electricity	Reporting functionalities	Electricity-S2	Electricity Loads	Reporting information regarding electricity consumption	None	reporting on current electricity consumption on building level	real-time feedback or benchmarking on building level	real-time feedback or benchmarking on appliance level	real-time feedback or benchmarking on appliance level with automated personalized recommendations	1		3	Level 3
Electricity	Reporting functionalities	Electricity-S3	Renewables	Reporting information regarding local electrcity generation	None	Current generation data available	Actual values and historical data	Performance evaluation including forecasting and/or benchmarking	Performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection	1	Only applicable in case of local energy generation	2	Level 2
Electricity	Reporting functionalities	Electricity-S4	Storage	Reporting information regarding energy storage	None	Current state of charge (SOC) data available	Actual values and historical data	Performance evaluation including forecasting and/or benchmarking	Performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection	1	Only applicable in case of local energy generation	0	Level 0
Electric vehicle charging		EV-S1	EV Charging	Charging capacity	not present	ducting (or simple power plug) available	0-9% of parking spaces has recharging points	10-50% or parking spaces has recharging point	>50% of parking spaces has recharging point	1	Always to be assessed (if domain is relevant)	2	Level 2
Electric vehicle charging	Storage & Connectivity	EV-S3	EV Charging - Grid	EV Charging Grid balancing	Not present (uncontrolled charging)	1-way controlled charging (e.g. including desired departure time and grid signals for optimization)	2-way controlled charging (e.g. including desired departure time and grid signals for optimization)			1	Only to be assessed if EV charging available on site	1	Level 1
Electric vehicle charging	Reporting functionalities	EV-S4	EV Charging - connectivity	EV charging information and connectivity	No information available	Reporting information on EV charging status to occupant	Reporting information on EV charging status to occupant AND automatic identification and authorization of the driver to the charging station (ISO 15118			1	Only to be assessed if EV charging available on site	2	Level 2

Domain	Theme	Code	Service group	Smart ready service	Functionality level 0 (as non-smart default)	Functionality level 1	Functionality level 2	Functionality level 3	Functionality level 4	part of the proposed simplified indicator	Preconditions / Dependency on other services or building types	Functionality level	
Monitoring and control	Controllability of Performance	MC-S1	TBS interaction control	Single platform that allows automated control & coordination between TBS + optimization of energy flow based on occupancy , weather and grid	None	Single platform that allows manual control of multiple TBS	Single platform that allows automated control & coordination between TBS	Single platform that allows automated control & coordination between TBS + optimization of energy flow based on occupancy, weather and grid signals		1	Always to be assessed	3	Level 3
Monitoring and control	Flexibility	MC-S2	Smart Grid Integration	Smart Grid Integration	None - No harmonization between grid and TBS; building is operated independently from the grid load	Demand side management possible for (some) individual TBS, but not coordinated over various domains	Coordinated demand side management of multiple TBS			1	Always to be assessed	1	Level 1
Monitoring and control	Information to occupants	MC-S3	Feedback - Reporting information	Central reporting of TBS performance and energy use	None	Central o rremote reporting of realtime energy use per energy carrier	Central or remote reporting of realtime energy use per energy carrier, combining TBS of at least 2 domains in	Central or remote reporting of realtime energy use per energy carrier, combining TBS of all domains in one		1	Always to be assessed	3	Level 3

LUT University

S3UNICA Interreg Europe

European Union European Regional Development Fund

SRI CALCULATION WITHOUT WEIGHTING FACTORS

MAX VALUE	Energy Saving and operation		Respond to user needs				Respond to needs of the grid	
	Energy savings on site	Maintenance & fault prediction	Comfort	Convenience	Health & wellbeing	Information to occupants	Flexibility for the grid and storage	
Heating	8	4	6	4	2	3	5	32
Domestic hot water	3	2	0	5	0	3	4	17
Cooling	8	4	7	7	3	3	6	38
Controlled ventilation	3	2	3	3	6	3	0	20
Lighting	3	0	2	2	0	0	0	7
Dynamic building envelope	3	2	3	4	3	3	0	18
Electricity	5	6	0	5	0	9	3	28
Electric vehicle charging	0	0	0	6	0	3	4	13
Monitoring and control	4	4	0	7	0	3	3	21
TOTAL	37	24	21	43	14	30	25	194
	19,07 %	12,37 %	10,82 %	22,16 %	7,22 %	15,46 %	12,89 %	100,00 %

SRI VALUE	Energy Saving and operation		Respond to user needs				Respond to needs of the grid	
	Energy savings on site	Maintenance & fault prediction	Comfort	Convenience	Health & wellbeing	Information to occupants	Flexibility for the grid and storage	
Heating	7	3	6	3	2	3	3	27
Domestic hot water	1	2	0	1	0	3	0	7
Cooling	7	2	6	6	2	3	4	30
Controlled ventilation	3	1	3	3	6	2	0	18
Lighting	3	0	2	2	0	0	0	7
Dynamic building envelope	1	0	1	1	0	0	0	3
Electricity	3	2	0	0	0	5	0	10
Electric vehicle charging	0	0	0	5	0	3	2	10
Monitoring and control	3	4	0	6	0	3	2	18
TOTAL	28	14	18	27	10	22	11	130
	21,54 %	10,77 %	13,85 %	20,77 %	7,69 %	16,92 %	8,46 %	100,00 %

SRI %	Energy Saving and operation		Respond to user needs				Respond to needs of the grid
	Energy savings on site	Maintenance & fault prediction	Comfort	Convenience	Health & wellbeing	Information to occupants	Flexibility for the grid and storage
Heating	88 %	75 %	100 %	75 %	100 %	100 %	60 %
Domestic hot water	33 %	100 %	Not applicable	20 %	Not applicable	100 %	0 %
Cooling	88 %	50 %	86 %	86 %	67 %	100 %	67 %
Controlled ventilation	100 %	50 %	100 %	100 %	100 %	67 %	Not applicable
Lighting	100 %	Not applicable	100 %	100 %	Not applicable	Not applicable	Not applicable
Dynamic building envelope	33 %	0 %	33 %	25 %	0 %	0 %	Not applicable
Electricity	60 %	33 %	Not applicable	0 %	Not applicable	56 %	0 %
Electric vehicle charging	Not applicable	Not applicable	Not applicable	83 %	Not applicable	100 %	50 %
Monitoring and control	75 %	100 %	Not applicable	86 %	Not applicable	100 %	67 %

Energy savings on site	Maintenance & fault prediction	Comfort	Convenience	Health & wellbeing	Information to occupants	Flexibility for the grid and storage
76 %	58 %	86 %	63 %	71 %	73 %	44 %
Energy Saving and operation		Respond to user needs				Respond to needs of the grid
69 %		71 %				44 %
SMART READINESS INDICATOR						
67,01 %						

SRI CALCULATION WITH WEIGHTING FACTORS

	Energy Saving and operation		Respond to user needs				Respond to needs of the grid
	Energy savings	Maintenance & fault prediction	Comfort	Convenience	Health & wellbeing	Information to occupant	Flexibility for the grid and storage
FACTOR TO SET	50 %	50 %	25 %	25 %	25 %	25 %	100 %
FACTOR TO SET	33 %		33 %				33 %
	16,7%	16,7%	8,3%	8,3%	8,3%	8,3%	33,3%

Figure 13 – Aggregation of impact scores to three key functionalities or to a single score

	Energy Saving and operation		Respond to user needs				Respond to needs of the grid	
MAX VALUE	Energy savings on site	Maintenance & fault prediction	Comfort	Convenience	Health & wellbeing	Information to occupants	Flexibility for the grid and storage	
Heating	6,99	5,39	4,62	1,50	2,31	1,62	12,93	35
Domestic hot water	2,62	2,69	0,00	1,88	0,00	1,62	10,35	19
Cooling	6,99	5,39	5,39	2,63	3,46	1,62	15,52	41
Controlled ventilation	2,62	2,69	2,31	1,13	6,93	1,62	0,00	17
Lighting	2,62	0,00	1,54	0,75	0,00	0,00	0,00	5
Dynamic building envelope	2,62	2,69	2,31	1,50	3,46	1,62	0,00	14
Electricity	4,37	8,08	0,00	1,88	0,00	4,85	7,76	27
Electric vehicle charging	0,00	0,00	0,00	2,26	0,00	1,62	10,35	14
Monitoring and control	3,50	5,39	0,00	2,63	0,00	1,62	7,76	21
TOTAL	32,33	32,33	16,17	16,17	16,17	16,17	64,66	194
	32,33	32,33	16,17	16,17	16,17	16,17	64,66	194
	16,67 %	16,67 %	8,33 %	8,33 %	8,33 %	8,33 %	33,33 %	100,00 %

	Energy Saving and operation		Respond to user needs				Respond to needs of the grid	
SRI VALUE	Energy savings on site	Maintenance & fault prediction	Comfort	Convenience	Health & wellbeing	Information to occupants	Flexibility for the grid and storage	
Heating	6,12	4,04	4,62	1,13	2,31	1,62	7,76	
Domestic hot water	0,87	2,69	0,00	0,38	0,00	1,62	0,00	
Cooling	6,12	2,69	4,62	2,26	2,31	1,62	10,35	
Controlled ventilation	2,62	1,35	2,31	1,13	6,93	1,08	0,00	
Lighting	2,62	0,00	1,54	0,75	0,00	0,00	0,00	
Dynamic building envelope	0,87	0,00	0,77	0,38	0,00	0,00	0,00	
Electricity	2,62	2,69	0,00	0,00	0,00	2,69	0,00	
Electric vehicle charging	0,00	0,00	0,00	1,88	0,00	1,62	5,17	
Monitoring and control	2,62	5,39	0,00	2,26	0,00	1,62	5,17	
TOTAL	24,47	18,86	13,86	10,15	11,55	11,85	28,45	119
	20,53 %	15,82 %	11,63 %	8,52 %	9,69 %	9,95 %	23,87 %	100,00 %

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SRI %	Energy Saving and operation		Respond to user needs				Respond to needs of the grid
	Energy savings on site	Maintenance & fault prediction	Comfort	Convenience	Health & wellbeing	Information to occupants	Flexibility for the grid and storage
Heating	88 %	75 %	100 %	75 %	100 %	100 %	60 %
Domestic hot water	33 %	100 %	Not applicable	20 %	Not applicable	100 %	0 %
Cooling	88 %	50 %	86 %	86 %	67 %	100 %	67 %
Controlled ventilation	100 %	50 %	100 %	100 %	100 %	67 %	Not applicable
Lighting	100 %	Not applicable	100 %	100 %	Not applicable	Not applicable	Not applicable
Dynamic building envelope	33 %	0 %	33 %	25 %	0 %	0 %	Not applicable
Electricity	60 %	33 %	Not applicable	0 %	Not applicable	56 %	0 %
Electric vehicle charging	Not applicable	Not applicable	Not applicable	83 %	Not applicable	100 %	50 %
Monitoring and control	75 %	100 %	Not applicable	86 %	Not applicable	100 %	67 %

Energy savings on site	Maintenance & fault prediction	Comfort	Convenience	Health & wellbeing	Information to occupants	Flexibility for the grid and storage
75,68 %	58,33 %	85,71 %	62,79 %	71,43 %	73,33 %	44,00 %
Energy Saving and operation		**Respond to user needs**				Respond to needs of the grid
67,00 %		73,32 %				44,00 %
SMART READINESS INDICATOR						
61,44 %						